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Excelling at youth level in competitive track and field athletics is not a prerequisite for later success

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25

Abstract

26 Enhancing our understanding of athlete development would be valuable for coaches, parents
27 and administrators to set realistic performance expectations and to advance youth sport
28 policy. To this end, a database of track and field performances was examined. Records of
29 134,313 performances by athletes aged between 12 and 35 years in sprinting, throwing,
30 jumping and middle distance events were analysed. Results revealed that a minority (Male, 9%;
31 Female, 13%) of top 20 ranked senior athletes were also ranked in the top 20 at Under 13
32 (U13). These results were supported by the finding that a minority of athletes retained their
33 top 20 ranking at subsequent age grades (36.3% U13-U15; 23% U13-U17; 13% U13-U20; 43.3%
34 U15-U17; 22.1% U15-U20; 41.8% U17-U20). By U20, less than 30% of athletes who had been
35 ranked in the top 20 at U13 were still listed on the national rankings. Examining a broader
36 sample of athletes revealed weak to moderate correlations between performances at different
37 age grades until at least Under 17-Under 20. These findings reinforce the message that
38 excelling at youth level in competitive athletics is not a prerequisite for senior success.

39 *Keywords:* early specialisation, youth success, youth sport, adolescent athlete

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Introduction

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Promising young athletes are routinely selected to talent development programmes such as specialised sport schools or club academies (van Rens, Elling, & Reijgersberg, 2015; Vaeyens, Güllich, Warr, & Philippaerts, 2009). Within sports that are measured in centimetres, grams, or seconds (termed CGS sports; e.g., track and field athletics), such selection is often on the basis of current performance levels (Andronikos, Elumaro, Westbury, & Martindale, 2015; Boccia et al., 2017). However, performances at youth level are thought to be relatively independent of long term potential due to the highly complex and nonlinear nature of athlete development (Abbott, Button, Pepping, & Collins, 2005; Abbott & Collins, 2002; Baker, Schorer, & Wattie, 2017). That said, there is a paucity of research tracking changes in performance over the development of young athletes (Boccia et al., 2017; Costa, Marinho, Bragada, Silva, & Barbosa, 2011). Enhancing our understanding of changes in performance across development would be valuable for coaches, parents and administrators to set realistic performance expectations and to advance youth sport policy (Shibli & Barrett, 2011; Tønnessen, Svendsen, Olsen, Guttormsen & Haugen, 2015).

Previous research has investigated the relationship between youth and adult success in a range of sports (Barreiros, Côté, & Fonseca, 2014; Durandt, Parker, Masimla, & Lambert, 2011; Güllich & Emrich, 2006; Moesch, Elbe, Hauge, & Wikman, 2011; Sokolavas, 2006). For example, Barreiros et al. (2014) found that only one third of athletes who had competed internationally at pre-junior level (≤ 16 years) in soccer, swimming, volleyball or judo also competed at senior level. Focusing on different age grades within youth sport, Durandt et al. (2011) found that the majority (76%) of players who competed at the national level at the Under 13 Craven Week rugby tournament in South Africa did not compete at the Under 18 tournament in subsequent years. Within track and field athletics specifically, Shibli and Barrett

67 (2011) examined a sample of 513 athletes ranked in the top 20 in the United Kingdom at Under
68 15; only 12% of these athletes retained this status at the Under 20 age grade. Boccia et al.
69 (2017) examined the performances of Italian athletes from the age of 12 to career termination
70 based on records from a national database. Only 0-5% of eventual top level (top 4%) senior
71 long and high jumpers were considered top level when they were 12-13 years of age. The
72 percentage of eventual top level senior athletes considered top level at 16 years of age ranged
73 from 10% (male long jumpers) to 59% (female high jumpers). Taken together, these studies
74 clearly illustrate that youth success is not a prerequisite for senior success.

75 While a number of studies have identified that the developmental trajectory of elite
76 athletes is nonlinear and highly variable (Abbott et al., 2005; Gulbin, Weissensteiner, Oldenziel,
77 & Gagné, 2013; Huxley, O'Connor, and Larkin, 2017), there is a lack of research quantifying
78 changes in athletic performance across age groups (Boccia et al., 2017; Costa et al., 2011).
79 Costa et al. (2011) tracked the performance progression of swimmers from 12 to 18 years.
80 Pearson correlation coefficients between performances at age 12 and age 18 were generally
81 low, ranging from -0.62 to 0.31. Correlations between performances at different ages were
82 typically strong for consecutive years (e.g., age 12 v age 13). However, correlations between
83 performances two and three years apart were much lower until approximately 16 years of age,
84 at which point strong correlations emerged and were interpreted as evidence of performances
85 stabilising. Within track and field athletics, Boccia et al. (2017) found a similar pattern of
86 correlations in the performances of Italian long and high jumpers. These studies suggest that
87 the performances of youth athletes may be expected to show high variation before the age of
88 16 years, although caution is urged in generalizing this finding to other athletic disciplines
89 which are underpinned by different physiological processes which develop at different rates
90 through adolescence (Lloyd & Oliver, 2012; Malina, Bouchard, & Bar-Or, 2004).

91 Limited research has investigated sex differences in the developmental trajectories of
92 track and field athletes. In an analysis of the 100 all-time best Norwegian athletes at each age
93 from 11 to 18, Tønnessen et al. (2015) found that male and female athletes performed almost
94 equally up to the age of 12, but that the rate of development in males was higher than that of
95 females from that age onwards. However, as the all-time best athletes were analysed at each
96 age grade, the development of individuals was not assessed. Boccia et al. (2017) tracked
97 athlete across age grades, and found that top senior female long and high jumpers were more
98 likely to have attained success at younger ages than their male counterparts, however their
99 results are restricted to these jumping events.

100 Understanding the manner in which athletic performances change through youth sport
101 is important for coaches, parents, and sport scientists working in talent development to set
102 realistic performance expectations and to design effective talent pathways. The Power of 10
103 (www.thepowerof10.info) is a publically accessible database which collates performances from
104 youth and senior track and field competitions in the United Kingdom. Such statistics databases
105 provide a wealth of information which can be used to study athlete development (Brazo-
106 Sayavera, Martínez-Valencia, Müller, Andronikos, & Martindale 2017; Boccia et al., 2017;
107 Saavedra-García, Gutierrez-Aguilar, Sa-Marques, & Fernandez-Romero, 2016). Specifically, we
108 explored the relationship between youth and adult success by conducting a retrospective
109 analysis of when top ranked senior athletes were first ranked in the top 20 for an age grade. As
110 retrospective and prospective approaches have produced differing perspectives on the
111 importance of youth success (Hollings & Hume, 2010), we subsequently examined the
112 proportion of athletes who had been ranked in the top 20 at youth level who (a) retained a
113 national ranking, and (b) retained a top 20 ranking in subsequent age categories. Finally, we

114 examined changes in performance across development for a broader sample of athletes by
115 correlating performances across age categories for all athletes for whom data was available.

116 **Method**

117 Data was acquired from a publicly-available website, www.powerof10.info, which
118 hosts information on athlete track and field performances and rankings within the United
119 Kingdom. All data used in this study is reported anonymously. Institutional ethical approval
120 was obtained for the project.

121 **Retrospective Analysis**

122 A retrospective analysis was undertaken to investigate the relationship between junior
123 and senior success. All senior athletes ranked in the top 20 of the senior age category for each
124 of eleven events (100m, 200m, 400m, 800m, 1500m, sprint hurdles, long jump, high jump, shot
125 put, javelin and discus) at the end of the 2014-15 track and field season were identified. Senior
126 athletes were defined as those who were too old to compete in the Under 20 category. Events
127 longer than 1500m and the 400m hurdles were not considered as Under 13 (U13) athletes do
128 not compete in these events, while neither pole vault nor hammer were considered due to the
129 specialist facilities required to train for these events. The top 20 ranking criterion was chosen
130 as this represented athletes who could reasonably be expected to make national semi-finals.
131 Furthermore, as the top 20 has previously been used in the analysis of athlete progression and
132 retention within UK athletics populations (Morris & Nevill, 2006; Shibli & Barrett, 2011), using
133 this category facilitated comparison with previous research.

134 A profile of each athlete is available on www.powerof10.info, including performances
135 and rankings at each age grade. These profiles were examined for each athlete's ranking at
136 each age grade. The top ranking for each athlete at each age grade was identified, irrespective
137 of event (i.e., if a future top long jumper was first nationally ranked in the 100m at Under 13

138 (U13), then he/she was listed as being nationally ranked at U13). Athletes for whom no
139 information was available at an age grade, whether through not competing or not performing
140 well enough to be ranked, were noted as “unlisted”. Where an athlete was ranked in the top
141 20 in multiple events (e.g., long jump and high jump), the highest ranking was used with all
142 duplicate records removed. The final sample was comprised of 184 senior men and 151 senior
143 women.

144 **Prospective Analysis**

145 All participants who appeared on the Power of 10 database in one of nine events
146 (100m, 800m, 1500m, sprint hurdles, long jump, high jump, shot put, discus, javelin) between
147 2005 and 2015 were identified. These events were chosen as they represent the core athletic
148 disciplines (sprint/hurdle, run, jump, throw). Due to the need to accurately identify athletes
149 across age categories, records without dates of birth were also excluded. Birthdates were
150 available for 67% of U13s, 69% of U15s, 79% of U17s, and 89% of U20 athletes.

151 Within the United Kingdom, youth athletes are organized within two- (U13, U15, U17)
152 or three-year (U20) age bands. Each athlete was only counted once per age category; the
153 analysis was therefore restricted to those athletes who were in the final year of each age
154 category. Due to various factors such as injury or school exams, it is possible that an athlete
155 may not achieve their best performance within their final year in an age grade. As such, the
156 performance (and ranking) identified for each athlete at each age grade was the best
157 performance that he/she had achieved across all years within the age grade. This process
158 resulted in 134,313 records being identified. These records were sorted into categories based
159 on age grade (i.e., U13, U15, U17, U20), event, and sex. Senior athletes were not considered
160 due to the relatively low numbers of senior athletes who could be traced back to junior ranks.

161 To perform a prospective analysis, all athletes who were ranked within the top 20 at
162 U13 were first identified. Only athletes who were old enough to have completed their time at
163 the higher age group were analysed (i.e., as data was available up to 2015, records from U13
164 athletes active in the years 2005-2008 were examined to compare performances at U13 and
165 U20, whereas to compare performances at U13 and U15, records from the years 2005-2013
166 were examined). The percentages of athletes who were ranked in the top 20 at U13 and who
167 (i) were still ranked on the Power of 10 database at subsequent age grades, and (ii) who
168 maintained their top 20 ranking at subsequent age grades, were calculated. This process was
169 then repeated for athletes ranked in the top 20 at U15 (tracked at U17 and U20) and at U17
170 (tracked at U20).

171 **Inter-relationships between performances at different age grades**

172 To analyse the relationship between performances at different age grades, the 134,313
173 records were processed using customised Microsoft Excel spreadsheets. These spreadsheets
174 matched individual records between two categories (e.g., Girls U13 long jump and Girls U15
175 long jump) on the basis of name and date of birth. The number of athletes who were shared
176 between categories ranged from 27 (male javelin U13-U20) to 1285 (male 100m U15-U17),
177 with a mean of 392 athletes per comparison.

178 **Data Analysis**

179 Descriptive statistics are presented on the age at which senior athletes were first
180 ranked within the top 20. To analyse whether top ranked senior male and female athletes
181 differed in the age at which they first achieved top 20 ranking, χ^2 Goodness of Fit tests were
182 applied. Cramer's V provided a measure of effect size, with values of 0.1, 0.3 and 0.5 indicating
183 small, medium and large effect sizes, respectively (Cohen, 1992). To analyse whether top 20
184 ranked juvenile male and female athletes differed in the proportion that retained a top 20

185 ranking, retained a ranking outside of the top 20, or were no longer listed on the national
186 rankings, χ^2 Goodness of Fit tests were again applied.

187 Pearson correlation coefficients were calculated to determine the relationship
188 between performances in the different age categories. This statistical procedure has previously
189 been applied to the longitudinal analysis of long and high jumpers (Boccia et al., 2017) and
190 swimmers (Costa et al., 2011). When repeated measures are correlated, relatively higher
191 correlation values may be expected due to covariates such as diet and training (Fallowfield,
192 Hale, & Wilkinson, 2005). Consequently, values of ± 0.2 - 0.5 were classified as weak correlations,
193 values of ± 0.5 - 0.7 were classified as moderate correlations, and values of ± 0.7 - 1.0 were
194 classified as strong to very strong correlations (Fallowfield et al., 2005), approximately
195 representing $\geq 5\%$, $\geq 25\%$ and $\geq 50\%$ shared variance respectively. Fisher's r to Z transformation
196 was used to test whether the correlation coefficients from male and female samples differed
197 (Field, 2009).

198 Results

199 Retrospective Analysis

200 Figure 1 illustrates the percentage of top 20 ranked male and female senior athletes who were
201 first ranked in the top 20 at each age grade. For both male and female athletes, the majority of
202 participants were unlisted at the U13 age grade, and even at U15 level, 60% of men and 49% of
203 women were still not listed on the database. By U17, the majority of top ranked senior athletes
204 were not only listed, but 48% of men and 58% of women were ranked within the top 20 for
205 that age grade. The proportion of male and female athletes did not differ at U13 $\chi^2 = 1.58$, $V =$
206 0.06 , $p = 0.21$, or U20 $\chi^2 = 1.30$, $V = 0.08$, $p = 0.25$. However, significant differences with a small
207 effect size emerged at both U15 $\chi^2 = 4.64$, $V = 0.11$, $p = 0.03$, U17 $\chi^2 = 6.89$, $V = 0.14$, $p = 0.008$.
208 Inspection of Figure 1 suggests that these differences are due to relatively more males than

209 being unlisted at both U15 and U17, and relatively more females than males being ranked in
210 the top 20 at both U15 and U17.

211 **Prospective Analysis**

212 The percentage of athletes who were ranked in the top 20 at one age grade, and who
213 (1) retained a national ranking, and (2) retained a top 20 ranking in subsequent age categories,
214 is summarised in Figure 2 and presented in additional detail in Table 1. It is clear that there is a
215 high turnover in the number of athletes who are ranked on the Power of 10 database, with the
216 highest proportion of athletes retained between adjacent age categories. Similarly, the
217 proportion of athletes who retained their top 20 ranking across age groups was lowest
218 between U13 and U20. Even between the two oldest age groups, on average only 41.8% of top
219 20 ranked U17 athletes were still ranked in the top 20 at U20 (range 32.6-50.0%).

220 Further inspection of Table 1 reveals that males and females show similar rates of
221 retention within the Power of 10 database, and retention of top 20 rankings. When data from
222 the different events was pooled, χ^2 Goodness of Fit tests revealed statistically significant
223 differences between the sexes in the proportion of athletes with no ranking, ranked outside of
224 the top 20, and ranked within the top 20. The comparison between males and females in the
225 transition from U13 to U15 showed a small effect: $\chi^2 = 32.80$, $V = 0.11$, $p < 0.001$, due to a
226 relatively higher number of males having no ranking at U15. While the remaining comparisons
227 showed statistically significant differences between the sexes, examination of the effect size in
228 these cases suggested that this result was due to the sample size rather than a genuine effect:
229 U13 to U17, $\chi^2 = 6.30$, $V = 0.06$, $p = 0.012$; U13 to U20, $\chi^2 = 7.93$, $V = 0.08$, $p = 0.005$; U15-U17,
230 $\chi^2 = 3.90$, $V = 0.04$, $p = 0.048$; U15 to U20, $\chi^2 = 10.8$, $V = 0.08$, $p = 0.001$; U17 to U20, $\chi^2 = 16.7$, V
231 $= 0.09$, $p < 0.001$.

Table 1.
Retention of top 20 ranked youth athletes in subsequent age grades by age and sex.

Sex	Event	U13-U15			U13-U17			U13-U20			U15-U17			U15-U20			U17-U20		
		N	%Com	%RTR	N	%Com	%RTR	N	%Com	%RTR	N	%Com	%RTR	N	%Com	%RTR	N	%Com	%RTR
Male	100m	146	76.0%	26.0%	115	43.5%	13.0%	65	18.5%	3.1%	192	74.5%	31.8%	124	33.1%	9.7%	138	67.4%	32.6%
	Hurdles	146	80.1%	31.5%	113	47.8%	16.8%	56	26.8%	12.5%	153	68.0%	39.9%	100	34.0%	22.0%	105	49.5%	39.0%
	800m	156	79.5%	33.3%	128	51.6%	21.9%	75	41.3%	9.3%	161	80.1%	39.1%	106	51.9%	17.9%	131	76.3%	38.9%
	1500m	160	78.1%	28.8%	128	66.4%	21.9%	75	38.7%	9.3%	164	79.9%	37.8%	114	48.2%	17.5%	130	70.0%	41.5%
	HJ	180	74.4%	29.4%	138	46.4%	20.3%	79	30.4%	13.9%	185	70.8%	39.5%	131	41.2%	16.8%	144	54.2%	40.3%
	LJ	153	56.2%	26.8%	118	33.9%	17.8%	70	20.0%	11.4%	136	68.4%	39.0%	82	42.7%	23.2%	120	69.2%	45.8%
	Discus	137	80.3%	39.4%	108	60.2%	23.1%	65	33.8%	16.9%	149	77.9%	49.7%	103	52.4%	28.2%	121	71.9%	49.6%
	Shot	132	76.5%	37.9%	102	50.0%	26.5%	57	29.8%	15.8%	149	75.8%	48.3%	100	42.0%	27.0%	116	58.6%	42.2%
	Javelin	132	72.0%	42.4%	104	51.9%	30.8%	58	17.2%	6.9%	151	74.2%	49.0%	102	30.4%	17.6%	109	56.0%	39.4%
Female	100m	157	83.4%	33.1%	120	58.3%	25.0%	66	36.4%	21.2%	155	70.3%	36.8%	97	41.2%	26.8%	98	69.4%	50.0%
	Hurdles	146	85.6%	38.4%	111	43.2%	20.7%	55	21.8%	10.9%	140	74.3%	45.7%	86	40.7%	25.6%	95	54.7%	38.9%
	800m	156	84.1%	38.2%	127	56.7%	23.6%	72	34.7%	16.7%	141	78.0%	46.1%	95	48.4%	23.2%	110	60.9%	43.6%
	1500m	149	84.8%	40.4%	124	55.6%	25.8%	70	28.6%	12.9%	132	78.0%	47.7%	89	42.7%	25.8%	102	59.8%	39.2%
	HJ	192	83.5%	36.6%	147	57.1%	25.2%	87	19.5%	11.5%	157	78.3%	42.7%	107	33.6%	21.5%	111	44.1%	36.0%
	LJ	163	83.4%	35.6%	124	55.6%	21.0%	70	24.3%	10.0%	144	72.9%	42.4%	99	35.4%	17.2%	106	58.5%	42.5%
	Discus	143	80.7%	41.4%	115	57.4%	29.6%	65	29.2%	15.4%	131	81.7%	57.3%	86	47.7%	33.7%	102	61.8%	50.0%
	Shot	36	86.1%	41.7%	34	70.6%	23.5%	72	29.2%	20.8%	*	*	*	*	*	*	*	*	*
	Javelin	29	93.1%	51.7%	40	55.0%	27.5%	60	31.7%	15.0%	*	*	*	*	*	*	*	*	*

Note: N refers to the total number of athletes in the sample who were ranked in the top 20 at the younger age grade. %Com refers to the percentage of athletes who were still competing at a high enough standard to be ranked in their final year at the older age grade. %RTR refers to the percentage of athletes who retained their top 20 ranking in the older age grade. U = Under. HJ = high jump. LJ = long jump. *Due to a change in weight during the period of investigation, no data was available for these events.

240

241 **Inter-relationships between performances at different age grades**

242 Pearson correlation coefficients describing the inter-relationships between
243 performances at different age grades are presented in Table 2. Correlations between
244 performances at U13 and all subsequent age grades were weak to moderate for both males
245 and females. Correlations between adjacent age grades (i.e., U13-U15; U15-U17; U17-U20)
246 tended to be larger than correlations between non-adjacent age grades. The strongest
247 correlations were evident for throwing events. Strong correlations between performances at
248 U17 and U20 existed for most events, especially in the throwing events.

249 Fourteen of the 54 comparisons (nine events x six age groups) showed a significant
250 difference ($p < 0.05$) in the strength of the correlation coefficient between male and female
251 samples. In all 14 cases, correlations were stronger within the female samples (significant
252 differences are highlighted by shaded cells within Table 2).

Table 2.

Pearson correlation coefficients indicating the relationship between performances at various age grades by event and by sex

Sex	Event	U13-U15		U13-U17		U13-U20		U15-U17		U15-U20		U17-U20	
		N	r [95% CI]	N	r [95% CI]	N	r [95% CI]	N	r [95% CI]	N	r [95% CI]	N	r [95% CI]
Male	100m	955	0.53 [0.48, 0.58]	387	0.42 [0.33, 0.50]	66	-0.04 [-0.28, 0.20]	1285	0.57 [0.53, 0.61]	278	0.35 [0.24, 0.45]	616	0.62 [0.57, 0.66]
	Hurdles	516	0.56 [0.50, 0.62]	195	0.39 [0.26, 0.50]	39	0.20 [-0.13, 0.48]	506	0.68 [0.63, 0.72]	109	0.49 [0.34, 0.62]	175	0.65 [0.55, 0.72]
	800m	1103	0.55 [0.50, 0.59]	471	0.43 [0.35, 0.50]	114	0.11 [-0.07, 0.29]	1169	0.63 [0.60, 0.67]	341	0.42 [0.33, 0.50]	662	0.66 [0.61, 0.70]
	1500m	1063	0.56 [0.51, 0.60]	490	0.39 [0.31, 0.46]	101	0.18 [-0.02, 0.36]	1115	0.63 [0.59, 0.66]	330	0.38 [0.28, 0.47]	637	0.65 [0.61, 0.70]
	High Jump	668	0.57 [0.52, 0.62]	243	0.45 [0.34, 0.55]	51	0.08 [-0.20, 0.34]	654	0.63 [0.58, 0.67]	184	0.33 [0.19, 0.45]	303	0.74 [0.68, 0.79]
	Long Jump	698	0.55 [0.49, 0.60]	298	0.45 [0.36, 0.54]	65	0.34 [0.11, 0.54]	574	0.69 [0.64, 0.73]	121	0.46 [0.30, 0.59]	363	0.70 [0.65, 0.75]
	Discus	407	0.65 [0.59, 0.71]	168	0.52 [0.40, 0.63]	40	0.51 [0.24, 0.71]	518	0.72 [0.67, 0.75]	150	0.57 [0.45, 0.67]	288	0.83 [0.79, 0.86]
	Shot	497	0.69 [0.64, 0.73]	205	0.56 [0.45, 0.64]	40	0.25 [-0.06, 0.52]	567	0.75 [0.71, 0.78]	165	0.53 [0.42, 0.64]	273	0.82 [0.77, 0.85]
	Javelin	408	0.63 [0.57, 0.69]	166	0.59 [0.48, 0.68]	27	0.38 [0.00, 0.66]	418	0.78 [0.74, 0.81]	106	0.64 [0.51, 0.74]	245	0.81 [0.76, 0.85]
Female	100m	1151	0.56 [0.52, 0.60]	370	0.44 [0.35, 0.52]	56	0.43 [0.19, 0.62]	889	0.64 [0.60, 0.68]	194	0.62 [0.53, 0.70]	298	0.73 [0.67, 0.78]
	Hurdles	1049	0.59 [0.55, 0.63]	310	0.36 [0.26, 0.46]	47	0.14 [-0.15, 0.41]	646	0.67 [0.63, 0.71]	120	0.42 [0.25, 0.55]	183	0.70 [0.61, 0.76]
	800m	1226	0.60 [0.57, 0.64]	462	0.46 [0.38, 0.53]	101	0.41 [0.23, 0.56]	846	0.69 [0.65, 0.72]	194	0.51 [0.39, 0.60]	293	0.77 [0.72, 0.81]
	1500m	810	0.64 [0.60, 0.68]	294	0.48 [0.39, 0.57]	59	0.62 [0.43, 0.76]	763	0.72 [0.69, 0.76]	208	0.56 [0.46, 0.65]	289	0.66 [0.59, 0.72]
	High Jump	912	0.57 [0.52, 0.61]	337	0.39 [0.30, 0.48]	36	0.46 [0.15, 0.68]	679	0.69 [0.65, 0.73]	125	0.55 [0.42, 0.66]	184	0.78 [0.71, 0.83]
	Long Jump	1200	0.58 [0.54, 0.61]	405	0.36 [0.27, 0.44]	81	0.13 [-0.09, 0.34]	798	0.69 [0.65, 0.72]	205	0.47 [0.36, 0.57]	276	0.76 [0.70, 0.80]
	Discus	466	0.67 [0.61, 0.71]	169	0.64 [0.54, 0.72]	35	0.45 [0.13, 0.68]	447	0.81 [0.78, 0.84]	129	0.65 [0.54, 0.74]	194	0.85 [0.81, 0.89]
	Shot	294	0.69 [0.63, 0.75]	141	0.43 [0.29, 0.56]	60	0.44 [0.21, 0.62]	*	*	*	*	*	*
	Javelin	189	0.74 [0.66, 0.80]	71	0.55 [0.37, 0.70]	37	0.38 [0.07, 0.63]	*	*	*	*	*	*

Note: values in square brackets indicate 95% confidence intervals ([Lower Limit, Upper Limit]); * indicates that no data is available for this comparison due to a change in the rules governing the weight of implements. Shaded cells indicate where significant differences between male and female samples were identified at $p < 0.05$.

Figure 3 further illustrates the typical relationships between performances at different age groups, using female 800m runners as an exemplar. Considerable variability is evident in the performances, even in comparisons where the correlations are strong. For example, athletes who progressed to run under 2 minutes 10 seconds (the qualifying time for the 2017 European U20 Championships 800m) as an U20 had run between 2 minutes 18 seconds and 2 minutes 36 seconds as U13s ($M = 2$ minutes 27 seconds, $SD = 5.9$ seconds), between 2 minutes 7 seconds and 2 minutes 28 seconds as U15s ($M = 2$ minutes 16 seconds, $SD = 4.4$ seconds), and between 2 minutes 3 seconds and 2 minutes 23 seconds as U17s ($M = 2$ minutes 11 seconds, $SD = 4.0$ seconds).

Discussion

The results of this study extend previous research by demonstrating that the prediction of adult and U20 performance from early youth performances is problematic across a wide range of disciplines, and across multiple age categories. Analyses of the age at which top 20 ranked senior athletes first achieved a top 20 ranking as a junior, of the percentage of top 20 ranked athletes retaining their top 20 ranking across different age grades, and of the correlations between performances at different age grades, all clearly indicated that performances at the lowest age grade of youth athletics (U13) have a weak relationship with performance at U20 or senior levels. This finding is consistent with previous research in a range of sports (e.g., Barreiros et al., 2014; Moesch et al., 2011; Sokolavas, 2006), including track and field athletics (Boccia et al., 2017; Huxley et al., 2017; Shibli & Barrett, 2011).

While the majority of senior athletes were not listed on the national rankings at U13, it is not clear whether this result is due to the limited number of performances held on the national database when these senior athletes were competing as juniors, or due to these athletes not competing in athletics at that point. For example, in 2005, 136 U13 male athletes

284 were ranked in the 100m. In 2015, 750 athletes were ranked in the equivalent category.
285 Consequently, caution is required in interpreting the differences between the “unlisted” and
286 “ranked outside the top 20” categories. Limited information is available on the age of first
287 athletic competition, but Boccia et al.’s (2017) finding that the average age of entry into
288 competition for Italian long and high jumpers was between 14 and 16 years of age is consistent
289 with our results. Furthermore, the age at which an athlete experienced their initial competition
290 is likely to be less important than the nature of their initial exposure to athletics; that is, the
291 extent to which the athlete engaged in deliberate play or deliberate practice, and whether the
292 athlete specialised in track and field or was engaged in a range of sports (Côté & Vierimaa,
293 2014; MacPhail, Gorely, & Kirk, 2003; Shibli & Barrett, 2011). Nevertheless, the finding that the
294 majority of seniors were not top ranked as U13 athletes reinforces the message that *excelling*
295 at the youngest level of competitive athletics is not a prerequisite for senior success.

296 This conclusion is reinforced when examining the percentage of athletes who retained
297 a top 20 ranking across age grades (Figure 2). At all age grades, only a minority of athletes
298 retained their top 20 ranking. This finding is consistent with that of Shibli and Barrett (2011),
299 who tracked 513 athletes ranked in the top 20 in 2005 through to 2010, and found that only
300 12% of athletes retained a top 20 ranking. In the present study, 22.1% of top 20 ranked U15
301 athletes were found to have retained their top 20 ranking. The difference between the two
302 figures may be due to the greater sample size in the current study (N = 1621 for the U15-U20
303 comparison), or the wider range of years over which athletes were tracked (2005-2015). The
304 present study extends Shibli and Barrett’s (2011) findings, by illustrating that the high turnover
305 in top ranked performers begins at U13, and is relatively consistent across events. The high
306 turnover is potentially not just related to holding a top ranking, as the results revealed that a
307 large proportion of athletes were no longer listed on the national rankings 4-6 years later on.

308 Again, the results are consistent with Shibli and Barrett's (2011) comparison of the U15 to U20
309 transition (44% still competing relative to 42% in the current study).

310 Examining the inter-correlations between performances at different age grades reveals
311 that the performance variability of top ranked athletes is also evident for the broader athletic
312 population. A strong relationship between performances at different age grades does not
313 emerge until at least U17-U20. Although there are slight differences between the absolute
314 values for the correlations in Italian long and high jumpers (Boccia et al. 2017) and those
315 reported by the present study, the general pattern of results is consistent across the two
316 studies on athletics, and that of Costa et al. (2011) in swimming. The magnitude of the
317 correlations, particularly between performances at U13 and U20, emphasise that the range of
318 performances from which high achieving athletes may develop is very broad. In the girls 800m
319 example, the top 256 ranked U13 girls from the 2016-17 season would be identified as
320 performing at a level from which, historically, performers capable of qualifying for the
321 European championships have developed. Especially when considered in light of previous
322 research which has found that peak athletic performance is not achieved until the mid-
323 twenties for explosive power/sprint events, or even later for endurance events (Allen &
324 Hopkins, 2015; Shibli & Barrett, 2011), these findings reinforce the need to delay selection for
325 development squads until late adolescence where possible (Abbott et al., 2005; Andronikos et
326 al., 2015).

327 Correlations between performances were highest for the throwing events, particularly
328 during late adolescence. This result suggests that greater confidence may be had in the
329 selection of talented female throwers during late adolescence, as there is no difference in the
330 weight of implements thrown by U20 and senior women. In contrast, the discus and shot
331 thrown by senior men are heavier than those thrown by U20 men. Consequently, further

332 tracking of athlete performances through senior level is required before firm conclusions can
333 be drawn regarding selections of male athletes.

334 While there were no differences between males and females on the majority of
335 measures, a number of potentially important differences emerged. Top ranked senior female
336 athletes were more likely to have been top ranked at U15 and U17 than their male
337 counterparts. Secondly, correlations across age grades for several events tended to be higher
338 in females than in males. These findings are likely due to females maturing earlier than males
339 (Cumming, Standage, Gillison, & Malina, 2008; Malina et al., 2004). Despite these sex
340 differences, it is important to note that approximately half of top ranked senior female athletes
341 were still unranked at U15, while the correlations, despite being larger than those for males,
342 were still not strong until U17-U20. Therefore, there does not appear to be any reason to vary
343 selection policies between male and female athletes until at least late adolescence.

344 There are a number of limitations with this study. Primarily, the database did not
345 contain sufficient data to trace athletes from youth levels through to the finish of their senior
346 career. A greater depth of historical data would allow more accurate conclusions to be drawn
347 regarding the relationship between youth and adult success. Secondly, as performances below
348 a certain standard were not recorded, the correlation coefficients calculated may
349 underestimate the actual value due to restricted range (Howell, 2012). However, the
350 consistency of findings from the age of initial top 20 ranking, and the percentage of athletes
351 who retained their top 20 ranking across age grades, support the pattern of results from the
352 correlation coefficients. Finally, when an athlete is not listed on the national database, it is not
353 clear whether that athlete has dropped out of the sport, or is simply no longer competing at a
354 high enough level to be ranked. Consequently, no conclusions can be drawn regarding dropout
355 from this data.

356 This study has presented a picture of youth athletics in the United Kingdom. Future
357 research should examine the extent to which key stakeholders are aware of this picture, and
358 what strategies they are implementing to provide an optimal youth sport experience (Bergeron
359 et al., 2015). While much previous research has focused on coaches' knowledge (Fiander,
360 Jones, & Parker, 2013; Lewis, Morgan, & Cooper, 2015; Andronikos et al., 2015), research
361 should also consider the knowledge and strategies implemented by parents (Elliott,
362 Drummond, & Knight, 2017; Harwood & Knight, 2016; Knight, Dorsch, Osai, Haderlie, & Sellars,
363 2016). Misunderstandings of youth development are likely to lead to problems in relation to
364 early specialisation such as dropout (Crane & Temple, 2015; Fraser-Thomas, Côté, & Deakin,
365 2008) and injury (Hall, Foss, Hewett, & Myer, 2015; Wilhelm, Choi, & Deitch, 2017).
366 Consequently, it is vital that any misunderstandings regarding high performance in juvenile
367 competitions be addressed.

368 In conclusion, analyses of a range of different variables indicate that performances at
369 the lowest grade of youth athletics (U13) have a weak relationship with performance at U20 or
370 senior levels. Consequently, administrators, coaches and parents need to consider what
371 structures are implemented at the level of national organization, club and practice session to
372 ensure an optimal youth development experience.

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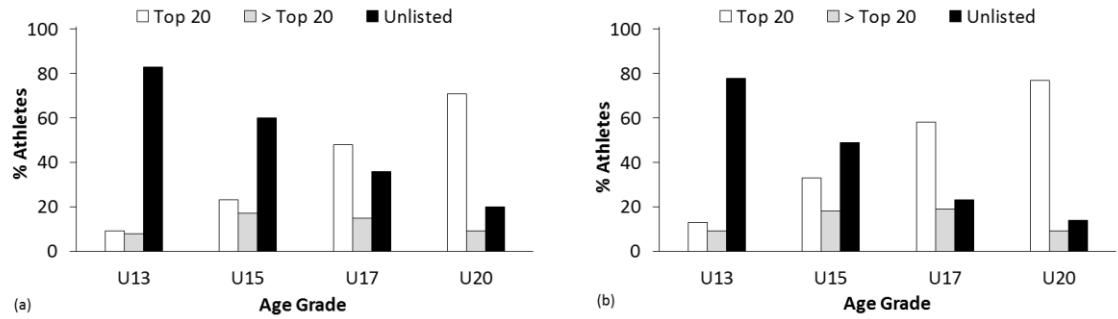
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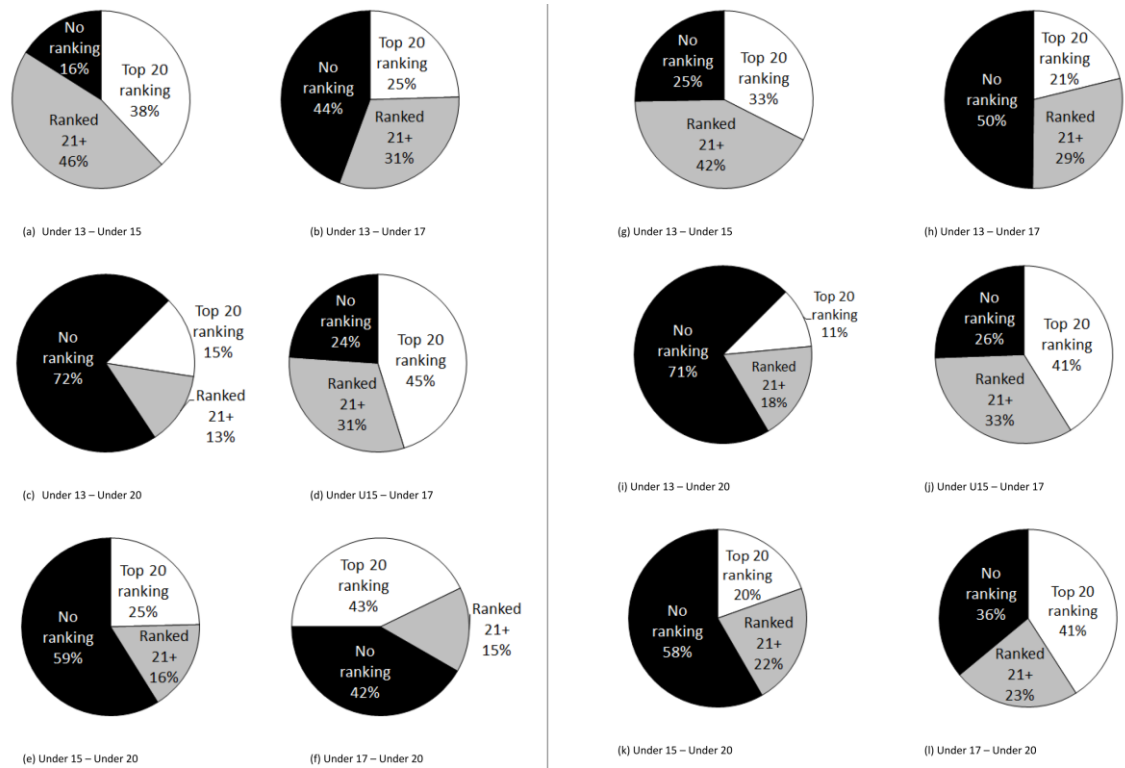
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Figure 1. The percentage of top 20 ranked (a) senior male, and (b) senior female athletes at the end of the 2014-15 track and field season who were ranked in the top 20 at each age grade. U = Under.

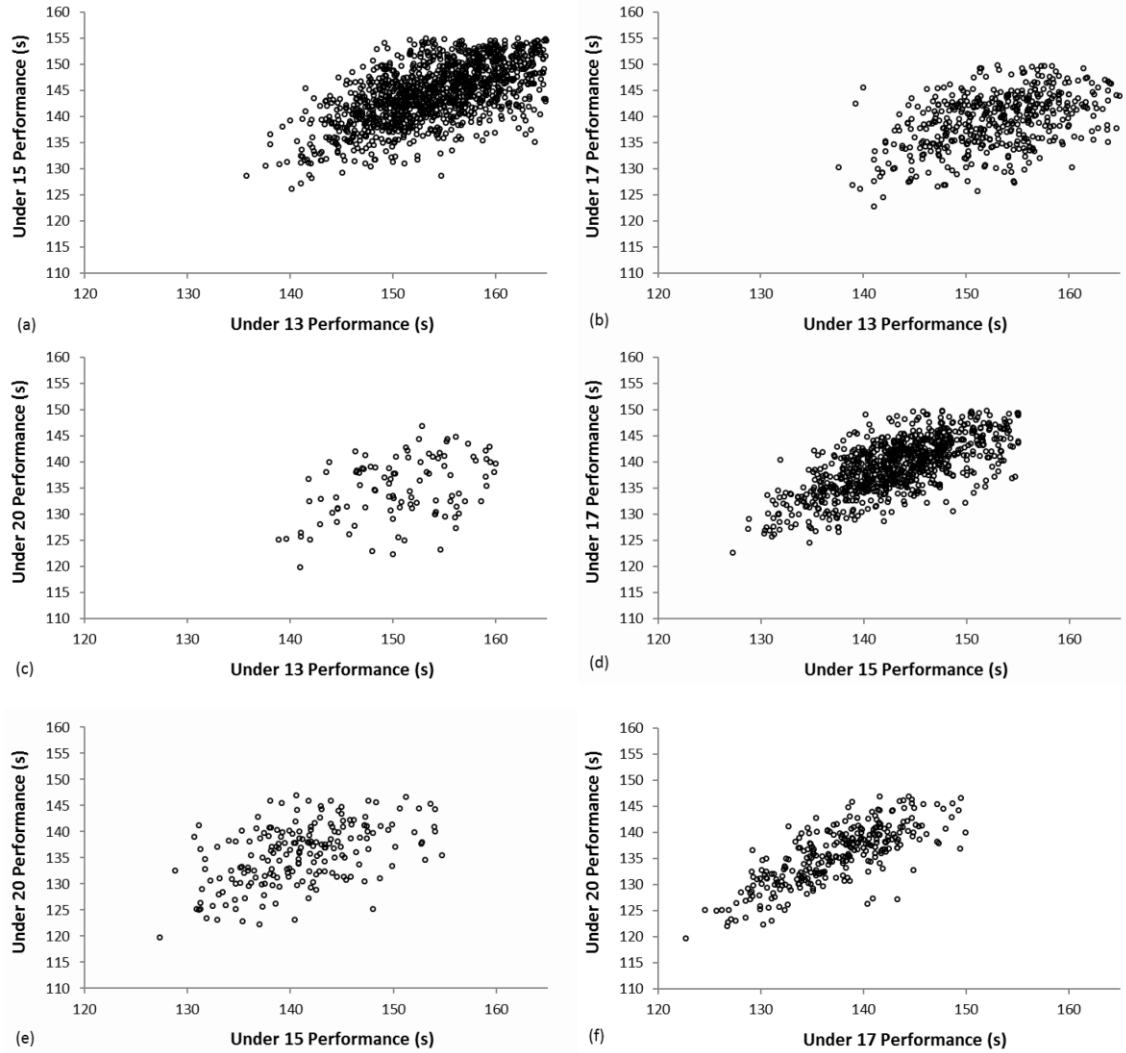


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500 *Figure 2. The proportion of top 20 ranked female (a to f) and male (g to l) athletes at the lower*
 501 *grade who retained their top 20 ranking (white portion), retained a national ranking outside*
 502 *the top 20 (grey ranking), or no longer appeared on the rankings (black portion).*

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505
 506 *Figure 3.* Illustration of the relationships between performances at various age groups for
 507 female 800m runners; (a) Under 13 relative to Under 15, (b) Under 13 relative to Under 17, (c)
 508 Under 13 relative to Under 20, (d) Under 15 relative to Under 17, (e) Under 15 relative to
 509 Under 20, (f) Under 17 relative to Under 20.